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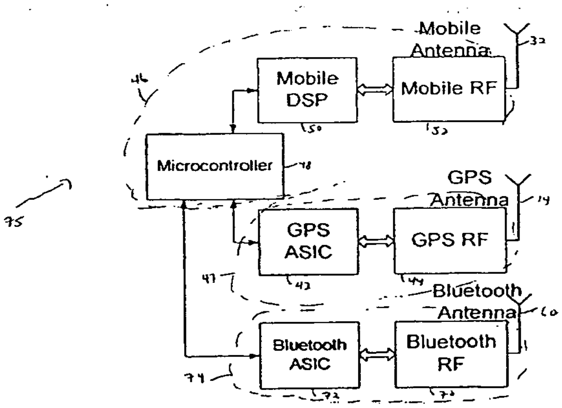
(54) Title: INTEGRATION OF BLUETOOTH FUNCTIONALITY WITH A GLOBAL POSITIONING SYSTEM



(57) Abstract: A method for localizing a moving object using a satellite based potioning system such as a global position system (GPS) (47) and a short range wireless system (74) such as a system that conforms to the Bluetooth specifications. Localization of a moving object is accomplished using GPS when sufficient satellites are visible. GPS correlation computations are performed either on-line with an application specific integrated circuit (ASIC) (42) or off-line with a digital signal processor (DSP). If insufficient satellites are visible, the locations of one or more nearby Bluetooth base stations are used to supplement or replace the GPS computation results to enable more accurate cellular phone localization. A cellular phone with a location detector function which integrates GPS and Bluetooth technology can be used for emergency localization in both outdoor and indoor settings. Bluetooth functionality is integrated in the cellular phone with a GPS system through the addition of a Bluetooth antenna (60), a Bluetooth RF radio (70), and a Bluetooth ASIC (72), all of which optionally are combined with components of prior art cellular phones. Integration of Bluetooth-GPS can also be used to improve navigational systems.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTEGRATION OF BLUETOOTH FUNCTIONALITY WITH A GLOBAL POSITIONING SYSTEM

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to a method of the integration of Bluetooth functionality with a Global Positioning System (GPS) to allow localization in satellite shielded areas, and more particularly to a location detector apparatus installed in cellular phones. The method of the present invention is also applicable to navigation devices..

In the U.S. legislation has been passed (Emergency Service Ruling U.S. FCC 911) mandating that a location detector be installed in every cellular phone in case of emergency. The E911 regulations specifies the required precision to be about 100 m. and the maximum time to complete an E911 call to be between 15 and 17 seconds. The position of the cellular phone should therefore be computed (acquisition time) within about four seconds. In Europe, a similar project called MORE has begun. The Emergency localization feature will be introduced on the cellular market starting from 2001.

There are two main competing technologies for localization. The first one is GPS, a satellite based positioning system which uses an array of 24 satellites (U.S.) or likewise the grid of Russian satellites (GLOSNASS). GPS has been adopted by project MORE as its localization technology. Using the civilian code of GPS (C/A), the precision is limited to about 100 m due to a degradation of the performance which is introduced by the U. S. Department of Defense. This degradation can be suppressed

using a Differential scheme called DGPS, in which case the precision is better than 20 m.

GPS receivers determine their position by computing the relative time of arrival of signals transmitted simultaneously from a multiplicity of satellites. The satellites transmit both satellite positioning data as well as data on clock timing. In order to compute the position of the receiver, the receiver uses transmitted satellite timing data, satellite positioning data and pseudoranges which are the time delays measured between the received signal from each satellite and a local clock. Generally, correlation methods are used to compute pseudoranges. The received signal which contains high rate satellite-specific repetitive code sequences is correlated with a stored replica of the appropriate code sequences.

Therefore the heart of a GPS system is a correlation engine, the purpose of which is compute the pseudoranges from the GPS device to at least four satellites. Using more time for integration of the correlations, it is possible to improve the sensitivity of the GPS devices, but this works only within a limited range (e.g. 20 m) from a window without walls separating the GPS device from a window access and provided that there are enough satellites in view. Hence, GPS fails for in-door computations, i.e. localization in buildings, e.g. in Manhattan skyscrapers. Schuchman et al (U.S. Patent No. 5,365,450) teach a cellular phone with a GPS receiver but the localization capabilities are limited to instances when there are enough satellites in view. Krasner (U.S. Patent No. 5,663,734), which is included by reference for all purposes as if fully set forth herein, demonstrates a fine example of a method for processing GPS signals. Using the Fast Fourier Transform (FFT) algorithm, very rapid computation of the pseudoranges is allowed by performing rapidly a large

number of correlation operations. The efficient processing of data using fast convolution methods allows the processing of signal at low received levels (e.g. when reception is poor due to partial blockage), but not when satellites are completely blocked.

The second main technology for localization is wireless triangulation. The method computes the ranges of a person carrying such a device to at least three base stations. This method requires that the base stations be fitted with the required software. Duffet -Smith (International Patent No. WO 94/28432) demonstrates an apparatus for the determination of the position of a roving receiver within a space shielded from receipt of signals from the transmission sources (such as a tunnel). The apparatus uses equipment for producing substitute signals locked in phase with signals from the transmission sources and a curvilinear transmission element extending within the shielded space for generating fields in the shielded space The main drawback of the triangulation method is that it does not ensure privacy because tracking of a mobile phone incorporating triangulation begins as soon as the mobile phone is turned on. As mentioned above, in Europe, the GPS method has already been chosen over wireless triangulation. In the U.S., a decision has not yet been reached

There is thus a widely recognized need for, and it would be highly advantageous to have, a positioning system which would rely on GPS technology but would also work when satellites are blocked such as in high-rise buildings and tunnels.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method for localizing a moveable object including the steps of: a) providing a short range wireless base station having a location; and b) interrogating the location of the short range wireless base station by the moveable object.

According to preferred embodiments the providing step includes establishing the location of the short range wireless system base station.

According to further features in preferred embodiments of the invention described below, the method also includes the steps of: c) receiving satellite based positioning system signals; d) processing the satellite based positioning system signals to extract satellite based positioning system intermediate location data; and e) reconciling the satellite based positioning system intermediate location data with a previously computed location of the moveable object. In a preferred embodiment, the reconciling reconciles the satellite based positioning system intermediate location data with both the location of the short range wireless base station and with a previously computed location of the moveable object to determine an updated location of the moveable object.. In a second embodiment, reconciling reconciles first the satellite based position system intermediate location data with a previously computed location of the movable object and then the result of the first reconciling with the location of the short range wireless base station to determine an updated location of the moveable object.

Preferably, the processing includes correlating the satellite based positioning system signals, and the satellite based positioning system intermediate location data include results of the correlating.

The method further includes either the step of transmitting the updated object location to a third party; or the step of displaying the updated object location.. In a preferred embodiment, transmitting is activated in response to an emergency.

According to one embodiment of the present invention, the processing of the satellite based positioning system signals to extract satellite based positioning system intermediate location data is effected in real time by steps including: (i) digitizing the received satellite based positioning system signal; and (ii) performing correlation computations on the digitized signal.

According to another embodiment of the present invention, the processing of the satellite based positioning system signals to extract satellite based positioning system intermediate location data is effected off line by steps including: (i) digitizing the received satellite based positioning system signal; (ii) storing the digitized signal, and (iii) performing correlation computations on the stored signal.

According to the present invention there is provided a cellular phone with a location detector function, including: a) at least one antenna for receiving satellite based positioning system signals and short range wireless communication system signals; b) a first mechanism for receiving satellite based positioning system signals from the at least one antenna and calculating satellite based positioning system intermediate location data based on the satellite based positioning system signals; and c) a second mechanism for receiving short range wireless communication system signals from the at least one antenna, wherein the received signal contains a substitute location of the cellular phone.

According to further features of preferred embodiments of the invention described below the apparatus further includes: d) a third mechanism for transmitting

location information connected to the satellite based positioning system intermediate location data and the substitute location. Preferably, the at least one antenna is used for transmitting the information via a cellular channel and the third mechanism includes: (i) a microcontroller for controlling the cellular phone; and (ii) a mobile RF radio for transmitting the information via the at least one antenna.

The first mechanism preferably includes: (i) a satellite based positioning system RF radio for receiving signals from the at least one antenna; and (ii) a satellite based positioning system application specific integrated circuit for calculating satellite based positioning system intermediate location data based on the received signals. The first mechanism preferably further includes: (iii) a digital signal processor for reconciling the satellite based positioning system intermediate location data with a previously computed location of the cellular phone.

In another embodiment, the first mechanism includes: (i) a satellite based positioning system RF radio for receiving signals from the at least one antenna; and (ii) a digital signal processor for calculating the satellite based positing system intermediate location data based on the received signals.

According to further aspects of preferred embodiments of the current invention, the second mechanism includes: (i) a short range wireless system RF radio for receiving signals from the at least one antenna; and (ii) a short range wireless system application specific integrated circuit for receiving a substitute position of the cellular phone from the short range wireless system RF radio.

According to the present invention there is provided a cellular phone with a location detector function including: a) An integrated RF radio including mobile RF functionality, satellite based positioning system RF functionality and short range

wireless system RF functionality; and b) at least one antenna for receiving satellite based positioning system signals and short range wireless communication system signals, operationally connected to the integrated RF radio.

Preferably, the apparatus further includes: c) an integrated digital signal processor (DSP) operationally connected to the integrated RF radio; and d) an integrated microcontroller, acting as a short range wireless communication system digital modem, operationally connected to the integrated DSP.

The present invention successfully addresses the shortcomings of the presently known configurations by providing a method of localization which integrates short range wireless system functionality (as exemplified by the Bluetooth specification)with a satellite based positioning system (as exemplified by the Global Position System (GPS)). More specifically, the integration of GPS and Bluetooth in the form of a location detector in a cellular phone can be used in the case of an emergency to locate an individual with a cellular phone which is shielded from satellite view as long as the cellular phone is near a Bluetooth access point as defined below.

In a preferred embodiment, the location detector feature on the cellular phone is activated by the user of the cellular phone or automatically in the case of an emergency such as a car accident, and allows the localization of the cellular phone within E911 guidelines.

Bluetooth can also be integrated into GPS based navigation devices to facilitate navigation in satellite-shielded environments.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 shows an outside view of a prior art cellular phone with a GPS based location detector;

FIG. 2 is a block diagram of a prior art cellular phone with GPS functionality using an application specific integrated circuit (ASIC) based correlation technique;

FIG. 3 is a block diagram of a prior art cellular phone with GPS functionality using a digital signal processing (DSP) based correlation technique;

FIG. 4 shows the network topology of a piconet;

FIG 5 shows an outside view of a cellular phone with a GPS and Bluetooth based location detector;

FIG 6 illustrates the programming of a Bluetooth access point;

FIG. 7 is a is a block diagram of a cellular phone with Bluetooth and GPS functionality using GPS application specific integrated circuit (ASIC) based correlation technique;

FIG. 8 is a is a block diagram of a cellular phone with Bluetooth and GPS functionality using a GPS digital signal processing (DSP) based correlation technique;

FIG. 9 is a block diagram of a cellular phone with a higher level of integration of Bluetooth and GPS functionality.

Figure 10 illustrates a navigation system using GPS and Bluetooth.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a method of integrating Bluetooth functionality with a Global Positioning System (GPS), and of related devices. A device of the present invention include a cellular phone with a location detector. The method can also be used to improve navigational devices. Specifically, the present invention can be used to localize individuals or objects, shielded from satellite view.

The principles and operation of the integration of Bluetooth functionality with a Global Positioning System according to the present invention may be better understood with reference to the drawings and the accompanying description.

Refer to Figure 1 which shows the external appearance of a prior art cellular phone **10** with a location detector function based on GPS technology. An emergency button **12** and a GPS antenna **14** are added to a cellular phone with a standard mobile antenna **32**. Although antennas **14** and **32** are separated in Figure 1, it should be evident to those skilled in the art that antennas **14** and **32** can be combined into one antenna. Signals **16**, **18**, **20**, and **22** from satellites **24**, **26**, **28**, and **30**, are periodically received when available by GPS antenna **14** and are used to calculate the user's position, as detailed below. Throughout the following discussion, it is assumed that the location detector function on cellular phone **10** is activated by an automatic trigger in the case of an emergency such as a car accident or by a user pressing push button **12** when the user desires to be located but does not have sufficient time to dial a third party, such as in the case of an illness. However, is should be evident to those skilled in the art, that the location detector function can be activated by other means than those previously mentioned and in non-critical situations. When the location detector function is activated, updated signals **16**, **18**, **20**, and **22** are used to calculate the

user's position and the user's position is automatically transmitted by mobile antenna **32** to a third party which is represented here as emergency station **36** (e.g. "911") via a signal **34**.

Figures 2 and 3 illustrate two embodiments of the inside of cellular phone **10** with a GPS location detector function, their differences being the technique used to perform correlation calculations.

Figure 2 is a block diagram of a first embodiment **40** of cellular phone **10**. An off the shelf GPS receiver chip set **47** which includes a GPS application specific integrated circuit ASIC **42** such as the SiRFstarI ASIC manufactured by the SiRF company (Santa Clara, California)along with a GPS RF radio **44** is added to a mobile phone chip set **46**. Mobile phone chip set **46** consists of a microcontroller **48**, mobile digital signal processor DSP **50**, and a mobile RF radio **52** with mobile RF radio **52** providing "mobile RF functionality". The operation of mobile phone chip set **46** is well known in the art and microcontroller **48** here acts as the host controller of cellular phone **10** and also as the communications controller.

Signals **16**, **18**, **20**, and **22** as they are received by GPS antenna **14**, are passed via GPS RF radio **44** (providing "satellite based positioning system RF functionality") to GPS ASIC **42**. GPS ASIC **42** digitizes (samples and quantizes) each of signals **16**, **18**, **20** and **22**, and performs the necessary correlation calculations in real time to derive GPS intermediate location data. GPS intermediate location data, which represents the intermediate step between the raw data contained in signals **16**, **18**, **20**, and **22** and the finalized computed updated location, and in the preferred embodiment includes the calculated correlation results, is passed to mobile DSP **50** or microcontroller **48**. Mobile DSP **50** or microcontroller **48** reconciles the GPS

intermediate location data computed by GPS ASIC **42** with a previously calculated position of cellular phone **10** to arrive at a newly computed updated position of cellular phone **10**. While signals **16**, **18**, **20**, and **22** continue to be processed to compute the position of cellular phone **10**, the updated position information is passed via mobile RF radio **52** to mobile antenna **32** for transmission. The usage of GPS ASIC **42** in embodiment **40** enables continuous localization and navigation. It can offer excellent acquisition time (less than 2 sec.) On the other hand, the drawback is that it requires a special ASIC.

Figure 3 is a block diagram of a second embodiment **53** of cellular phone **10** which is a digital signal processing based solution in which each of the received signals **16**, **18**, **20**, and **22** is digitized (i.e. sampled and quantized) and stored. Mobile DSP **50** (reconfigured to include the necessary software) performs correlation on the stored samples (typically 4 Mbit of RAM) to derive GPS intermediate location data, and reconciles the GPS intermediate location data with a previously computed position of cellular phone **10** to arrive at a newly computed updated position of cellular phone **10** as per prior art U.S. patent number 5,663,734 described above. As an alternative, reconciliation of the GPS intermediate location data with the previously computed position of cellular phone **10** can be performed in microcontroller **48**. The localization is computed off-line after the samples are stored in embodiment **53**. Therefore, in contrast with the device **40** of Figure 2, the updated position information which is calculated and passed via mobile RF radio **52** to mobile antenna **32** for transmission corresponds to an earlier in time position of cellular phone **10**. This solution therefore cannot provide continuous localization.

A significant drawback of embodiment **53** relative to embodiment **40** is that during the emergency call, the person cannot talk simultaneously with the GPS computations. Note that a typical mobile DSP **50** is busy at least 25% to 50% performing the voice DSP algorithms including compression and decompression. Because a conversation with an emergency station cannot be interrupted, the GPS computation time (normally a few seconds) might be doubled due to the priority of voice DSP algorithms and embodiment **53** may not satisfy the requirement that an emergency call be completed by between 15-17 seconds. In this example, mobile DSP **50** is used to perform both the voice DSP algorithms and the GPS locator correlation calculations, however it is evident to those skilled in the art that a separate DSP could also be used for GPS calculations. A second DSP would allow simultaneous talking and GPS computations but would increase the cost of the location detector device installed in cellular phone **10**.

The embodiments represented in Figures 2 and 3 assume that cellular phone **10** is digital but an analog cellular phone could instead be used, provided that a mobile DSP **50** is added to the base analog cellular phone.

The integration of GPS into cellular phone **10** as illustrated in figures 1, 2, and 3, would be sufficient in the situation that satellites are not blocked. It will now be discussed how the addition of Bluetooth functionality will allow localization for in-door computations, and for outdoor situations where satellites are blocked such as in tunnels.

Bluetooth technology is an open specification for wireless communication of data and voice in a short range wireless communication system. It is based on a low-cost short-range radio link, built into a 9 x 9 mm microchip, facilitating connections

for stationary and mobile communication environments. Bluetooth technology allows for the replacement of the many proprietary cables that connect one device to another with one universal short-range radio link. Due to its advantages, Bluetooth is expected to be installed in buildings and offices for the purpose of Home networking, Small Office Networking, Information attainment services and proximity mobile communication. Bluetooth can also be installed in tunnels and other places where satellites are blocked. The fact that the range of Bluetooth is 10 m, but even if extended to 100 m will still meet E911 requirements makes it the simplest solution for in-door or outdoor satellite-blocked localization. In the context of this invention, a range up to 100 m is defined as a "short range".

Figure 4 illustrates a piconet **56** which is a collection of devices (two devices are shown in Figure 4) connected via Bluetooth technology in an ad hoc function. Before any connections in a piconet are created, devices **61** and **54** are in STANDBY mode. In this mode, an unconnected unit periodically "listens" for messages every 1.28 seconds. Each time a device wakes up, it listens on a set of 32 hop frequencies defined for that unit. The number of hop frequencies varies in different geographic regions; 32 is the number for most countries (except Japan, Spain and France). The connection procedure is initiated by any of the devices which then becomes master. In the present example, device **61** is a cellular phone, and device **54** is configured as a Bluetooth access point i.e. a base station that is configured to send its location, on request, to cellular phone **61**. The connection procedure is assumed to be initiated when the location detector function on cellular phone **61** (see figure 5) is activated causing cellular phone **61** to become a master. Because the address of nearby stationary device **54** is initially unknown by cellular phone **61**, a connection is made

by an INQUIRY message sent by cellular phone **61** followed by a subsequent PAGE message.

Refer to Figure 5 which shows the exterior of a cellular phone **61** of the present invention, with a location detector function based on GPS and Bluetooth technology. Externally, cellular phone **61** is identical to cellular phone **10** of Figure 1 except for the addition of a Bluetooth antenna **60**. Although antennas **14, 32**, and **60** are shown separated in Figure 3, it should be evident to those skilled in the art that antennas **14, 32**, and **60** can be combined into one or two antennas. When emergency push-button **12** is pushed or the location detector function is automatically activated, in addition to the GPS processing described above, cellular phone **61** initiates the transmission, via Bluetooth antenna **60**, of an INQUIRY message via a signal **62**, which is answered by device **54**. Cellular phone **61** then forms piconet **56** with device **54**. According to the Bluetooth standard, piconet **56** could contain up to 8 units. Device **54** transmits its location (latitude, longitude and altitude) via a return signal **64** to Bluetooth antenna **60**. Device **54**'s location (which functions as a "substitute location" for cellular phone **61**) can be used by cellular phone **61** to determine the position of cellular phone **61** either in addition to the results of the GPS calculations or in replacement of them (as explained in more detail below).

The location (latitude, longitude, and altitude) of nearby stationary device **54** is previously programmed using a special purpose computer **66** such as a laptop or personal digital assistant as shown in Figure 6. Upon installation of device **54**, special purpose computer **66** computes the location of device **54** using GPS data in the case of outdoor computations. For in-door computations, computer **66** is equipped with a software program which allows computer **66** to compute device **54**'s position from the

GPS position of the building and a computerized map of the building (including floors and room numbers) in which device **54** is being installed. The computed location is transmitted by a Bluetooth wireless modem **68** to device 54. Once device **54** has had its location programmed, it is called a "Bluetooth access point" or a "Bluetooth base station" and can be used for cellular phone localization purposes as explained above.

Alternatively device **54** is allocated a unique identification number and device **54**'s location (street address, floor number, room number etc.) is recorded in a lookup table (not shown). When queried, device **54** transmits its identification number (instead of or in addition to device **54**'s location) to cellular phone **61** via return signal **64**. A lookup table is used to determine the location of device **54** (and hence cellular phone **61**) corresponding to the received identification number. This alternative eliminates the need for the pre-programming, as illustrated in Figure 6, of location (latitude, longitude, and altitude) of device 54.

In the discussion above it is assumed that for privacy purposes cellular phone **61** does not initiate the Bluetooth connection procedure unless the location detector function is activated by the user or an automatic trigger, however it should be evident to those skilled in the art that initiation of the connection procedure could also be the default mode of cellular phone **61**. In the latter case, whenever cellular phone **61** is near a base station such as device **54**, device **54** transmits the location of device **54** (or alternate data such as an identification number) via signal **64** to Bluetooth antenna **60**. Cellular phone **61** uses the Bluetooth location data together with the GPS intermediate location data in order to periodically update the estimate of the location of mobile **61** (as described below). Transmission of the updated position information to station **36** via signal **34** still only occurs upon activation of the location detector.

Figure 7 is a block diagram of one embodiment **75** of cellular phone **61** with Bluetooth functionality. A Bluetooth chip set **74** is added to GPS chip set **47** and mobile phone chip set **46**. The functionality of GPS chip set **47** and mobile phone chip set **46** are as described in Figure 2. Bluetooth chip set **74** contains a Bluetooth RF radio **70**, providing "short range wireless system RF functionality" and a Bluetooth ASIC **72**, which is essentially a digital modem that provides "Bluetooth ASIC functionality". Alternatively, Bluetooth ASIC functionality can be provided partially by Bluetooth ASIC **72** and partially by a reconfigured microcontroller **48** through a partition of the Bluetooth protocol stack with the lower levels of the protocol implemented on Bluetooth ASIC **72** and the higher levels on microcontroller **48**. Bluetooth ASIC **72** can be developed using the Bluetooth specification or by using a development kit such as the one offered by Symbionics Ltd., Cambridge, England (a subsidiary of Cadence Design Systems, Inc., San Jose, California, USA).

The location of Bluetooth access point **54** which is received by Bluetooth antenna **60** from device **54** is passed via Bluetooth RF radio **70** to Bluetooth ASIC **72** and on to mobile DSP **50** or to microcontroller **48** where it is reconciled with GPS intermediate location data as discussed below.

Figure 8 is a block diagram of a second embodiment **77** of cellular phone **61** with Bluetooth functionality. Bluetooth receiver chip set **74** is added to GPS RF radio **44** and mobile phone chip set **46**. The operation of GPS RF radio **44** and mobile phone chip set **46** are as described in Figure 3. The operation of Bluetooth chip set **74** is as described in Figure 7.

In both embodiments **75** and **77** as shown in Figures 7 and 8, mobile DSP **50** uses the GPS intermediate location data as long as this data are sufficient to obtain a

reliable position. The GPS intermediate location data is reconciled with the previously computed position of cellular phone **61** through an algorithm such as a Kalman filter that is run by mobile DSP **50**. In one embodiment of the current invention, microcontroller **48** monitors the position error covariance, which is a by-product of the Kalman filter algorithm to determine whether GPS intermediate location data are sufficient. If cellular phone **61** is close to a Bluetooth access point (in our example device **54**) which is programmed to send its location to mobile Bluetooth receiver **74**, and the Bluetooth connection procedure has been initiated, the Bluetooth received location can also be reconciled with the GPS intermediate location data and the previously computed cellular phone position to arrive at the updated position of cellular phone **61**. Bluetooth reconciliation can occur in one of two ways:

- If the results of the reconciliation of GPS intermediate location data with the previously computed position of cellular phone **61** turn out to be totally unreliable as in the case of the position error covariance from the Kalman filter reaching a preset validity threshold, then the position of Bluetooth access point **54** are used instead by DSP **50** as a replacement for an updated position of cellular phone **61**. This is normally the case for in-door locations.
- The position of Bluetooth access point **54** is passed to mobile DSP **50** and is used as a complement to missing GPS data, e.g. in case less than four satellites are in view. . Dead-Reckoning is the GPS terminology for providing location data which are in addition to the satellite data. According to the prior art, Dead-Reckoning data are provided by a compass or a gyro and are added to the Kalman filter state variables when performing the reconciliation. The term "Dead-Reckoning" is understood in the context of the present invention to refer to reconciliation of

GPS intermediate location data with the previously computed position of cellular phone **61** by the Kalman filter. Here, the received position of Bluetooth access point **54** provides the Dead Reckoning data, establishing a new method of Dead Reckoning.

In another embodiment of the current invention, reconciliation is performed in two steps. Mobile DSP **50** first reconciles GPS intermediate location data with the previously computed cellular phone position to arrive at a GPS finalized location. Mobile DSP **50** then reconciles the GPS finalized location with the position of Bluetooth access point **54** to arrive at the updated position of cellular phone **61**.

As an alternative to reconciliation procedures performed by mobile DSP **50**, that are described above, reconciliation can be instead performed by microcontroller **48** (reconfigured to include the necessary software) using a "simple" Kalman filter or data fusion algorithm, assuming that microcontroller **48** is not powerful enough to run a full Kalman filter. A full Kalman filter is a multidimensional adaptive filter, the coefficients of which are adapted each time there are new input data. In a "simple" Kalman filter, the computational burden is reduced by, for example, adapting the coefficients every N-th time that new data are input, or by using a filter of reduced dimensionality. See, for example, R. G. Brown and P. Y. C. Hwang, *Introduction to Random Signals and Applied Kalman Filtering, Third Edition*, John Wiley & Sons, 1997 The "simple" Kalman filter is less CPU-consuming but performs sub-optimally to a full Kalman filter algorithm.

It will be evident to those experts in the art that higher levels of integration of GPS and Bluetooth locator technology in cellular phones are also possible with this invention. Figure 9 shows a possible configuration **83** where all RF radios **44**, **52**, and

70 are integrated into one RF radio **78** and Bluetooth ASIC 72 along with GPS ASIC **42** are integrated with microcontroller **48** to form advanced microcontroller block **82**. In addition, although mobile antenna 32, GPS antenna **14**, and Bluetooth antenna **60** are shown as separate units in Figure 9, it should be evident to those skilled in the art that mobile antenna 32, GPS antenna **14**, and Bluetooth antenna **60** can be combined into fewer than three antennas. An advanced mobile DSP **80** can, if desired, perform GPS correlation and reconciliation of position data, along with its usual voice DSP algorithms. In addition to acting as a host controller and communication controller, advanced microcontroller 82 acts as a Bluetooth digital modem, and can, if desired, monitor position error covariance, and perform position reconciliation.

In embodiments 75, 77, and 83 illustrated in Figures 7, 8, and 9, transmission of the updated position information via mobile antenna 32 is powered off when microcontroller **48** or **82** determines that third party 36 has received signal **34**. In addition, microcontroller **48** or **82** disables GPS computations when not needed to save power.

In a different embodiment of the present invention, reconciliation is performed by a GPS base station server (not shown), rather than by cellular phone **61** or by the cellular phone represented by embodiment **83**. GPS intermediate location data along with the position of Bluetooth access point **54**, if necessary, are sent by microcontroller **48** or **82** using mobile antenna **32** to a GPS base station server (not shown). At the GPS base station server, these data are reconciled with the previously computed cellular phone position using an algorithm such as the Kalman filter. The GPS base station server then sends the updated position directly to third party **36**.

Although the integration of Bluetooth GPS has been described above in the context of a location detector for a cellular phone, integration of Bluetooth-GPS can also be used for other purposes such as improving a navigation GPS in a moving vehicle as shown in embodiment **87** of Figure 10. In this context Bluetooth is used as an additional localization device in places where satellites are blocked such as in a tunnel **100**. Bluetooth base stations **96** (only one shown here) with a range of 100m are located every 100 m in a tunnel **100**. Because moving vehicle **92** is in tunnel **100**, GPS antenna **98** does not receive GPS signals, however in other embodiments GPS signals are received by antenna **98**. Whenever moving vehicle **92** approaches a Bluetooth base station **96**, Bluetooth base station **96** sends its location via signal **104**. The location of Bluetooth base station **96** and GPS intermediate location data are reconciled as described above and the location of moving vehicle **92** is in one embodiment of the current invention displayed on navigation display **90**.

In the context of localization as described above, mobile antenna **32**, can be used to GPS intermediate location data, the position of Bluetooth access point **54**, in addition to or in place of the updated position of the cellular phone. All such information is referred to in this invention as "location information connected to the satellite based positioning system intermediate location data and the substitute location".

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

WHAT IS CLAIMED IS

1. A method for localizing a movable object comprising the steps of:

a) providing a short range wireless base station having a location; and

b) interrogating said location of said short range wireless base station by the moveable object.

2. The method of claim 1, wherein said providing includes establishing said location of said short range wireless system base station.

3. The method of claim 1, further comprising the steps of:

c) receiving satellite based positioning system signals;

d) processing said satellite based positioning system signals to extract satellite based positioning system intermediate location data; and

e) reconciling said satellite based positioning system intermediate location data with a previously computed location of said moveable object.

4. The method of claim 3, wherein said reconciling reconciles said satellite based positioning system intermediate location data with both said location of said short range wireless base station and with a previously computed location of said moveable object to determine an updated location of said moveable object.

5. The method of claim 3, wherein said reconciling reconciles first said satellite based position system intermediate location data with a previously computed

location of said movable object and then the result of said first reconciling with said location of said short range wireless base station to determine an updated location of said moveable object.

6. The method of claim 3, wherein said processing includes correlating said satellite based positioning system signals, and wherein said satellite based positioning system intermediate location data include results of said correlating.

7. The method of claim 3 , further comprising the step of:

f) transmitting said updated object location to a third party.

8. The method of claim 8, wherein said transmitting is activated in response to an emergency.

9. The method of claim 3 ,further comprising the step of:

f) displaying said updated object location.

10. The method of claim 3 wherein said processing of said satellite based positioning system signals to extract satellite based positioning system intermediate location data is effected in real time by steps including:

(i) digitizing said received satellite based positioning system signal;

(ii) performing correlation computations on said digitized signal.

11. The method of claim 3, wherein said processing of said satellite based positioning system signals to extract satellite based positioning system intermediate location data is effected off line by steps including:

(i) digitizing said received satellite based positioning system signal;

(ii) storing said digitized signal, and

(iii) performing correlation computations on said stored signal.

12. A cellular phone with a location detector function, comprising:

a) at least one antenna for receiving satellite based positioning system signals and short range wireless communication system signals;

b) a first mechanism for receiving satellite based positioning system signals from said at least one antenna and calculating satellite based positioning system intermediate location data based on said satellite based positioning system signals; and

c) a second mechanism for receiving short range wireless communication system signals from said at least one antenna, wherein said received signal contains a substitute location of the cellular phone.

13. The apparatus of claim 12, further comprising:

d) a third mechanism for transmitting location information connected to said satellite based positioning system intermediate location data and said substitute location.

14. The apparatus of claim 13, wherein said at least one antenna is used for transmitting said information via a cellular channel and wherein said third mechanism includes:

(i) a microcontroller for controlling the cellular phone; and

(ii) a mobile RF radio for transmitting said information via said at least one antenna.

15. The apparatus of claim 12, wherein said first mechanism includes:

(i) a satellite based positioning system RF radio for receiving signals from said at least one antenna; and

(ii) a satellite based positioning system application specific integrated circuit for calculating said satellite based positioning system intermediate location data based on said received signals.

16. The apparatus of claim 15, wherein said first mechanism further includes:

(iii) a digital signal processor for reconciling said satellite based positioning system intermediate location data with a previously computed location of said cellular phone.

17. The apparatus of claim 12, wherein said first mechanism includes:

(i) a satellite based positioning system RF radio for receiving signals from said at least one antenna; and

(ii) a digital signal processor for calculating said satellite based positioning system intermediate location data based on said received signals.

18. The apparatus of claim 12, wherein said second mechanism includes:

(i) a short range wireless system RF radio for receiving signals from said at least one antenna;

(ii) a short range wireless system application specific integrated circuit for receiving said substitute location of the cellular phone from said short range wireless system RF radio.

19. A cellular phone with a location detector function comprising:

a) An integrated RF radio including mobile RF functionality, satellite based positioning system RF functionality and short range wireless system RF functionality; and

b) at least one antenna, for receiving satellite based positioning system signals, and short range wireless communication system signals, operationally connected to said integrated RF radio.

20. The apparatus of claim 19, further comprising:

c) an integrated digital signal processor, operationally connected to said integrated RF radio.

21. The apparatus of claim 19, further comprising:

d) an integrated microcontroller, acting as a wireless communication system digital modem, operationally connected to said integrated digital signal processor.

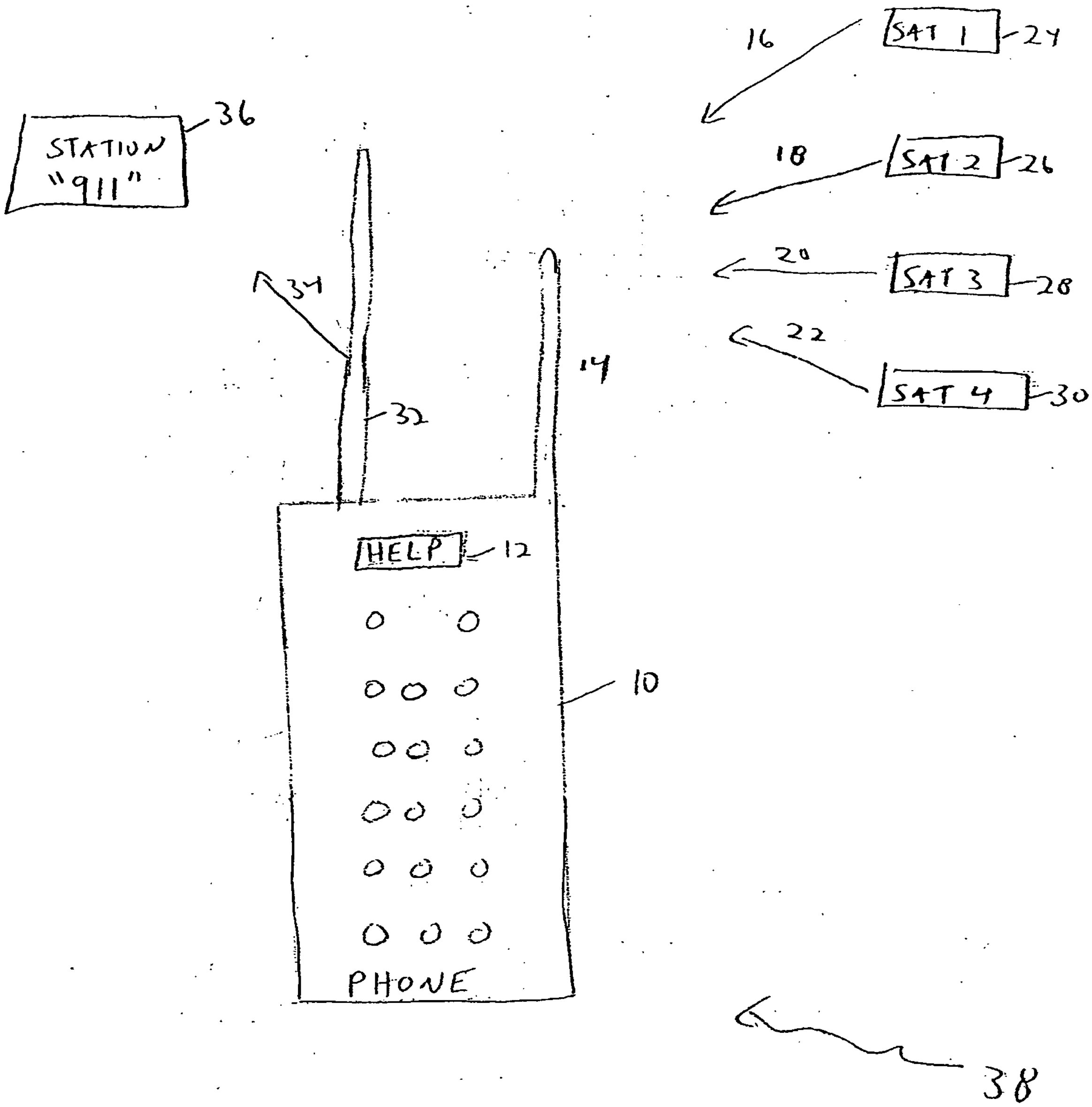


FIG 1 (PRIOR ART)

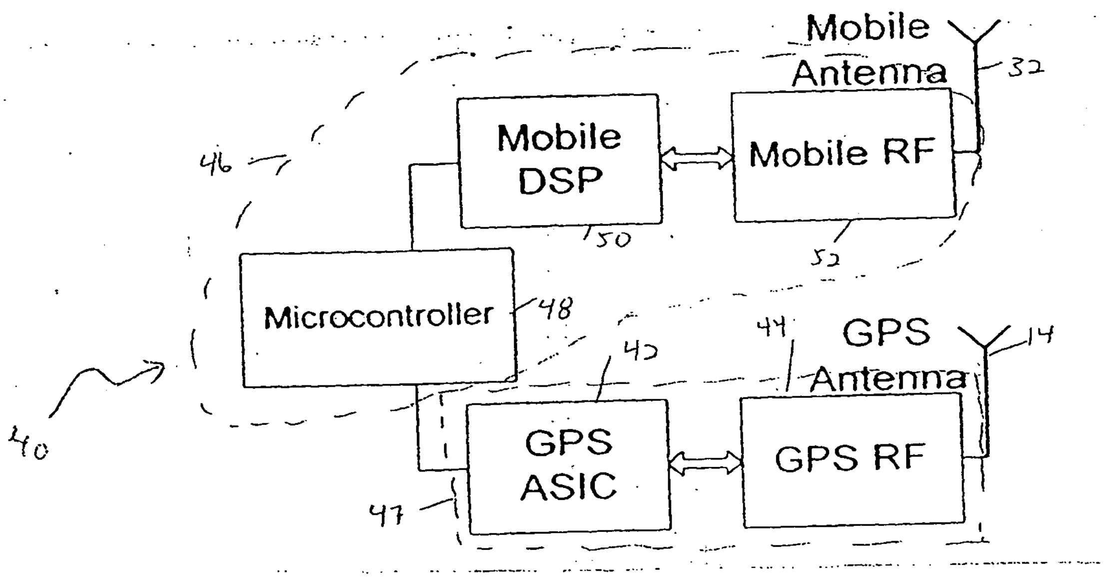


FIG 2 (PRIOR ART)

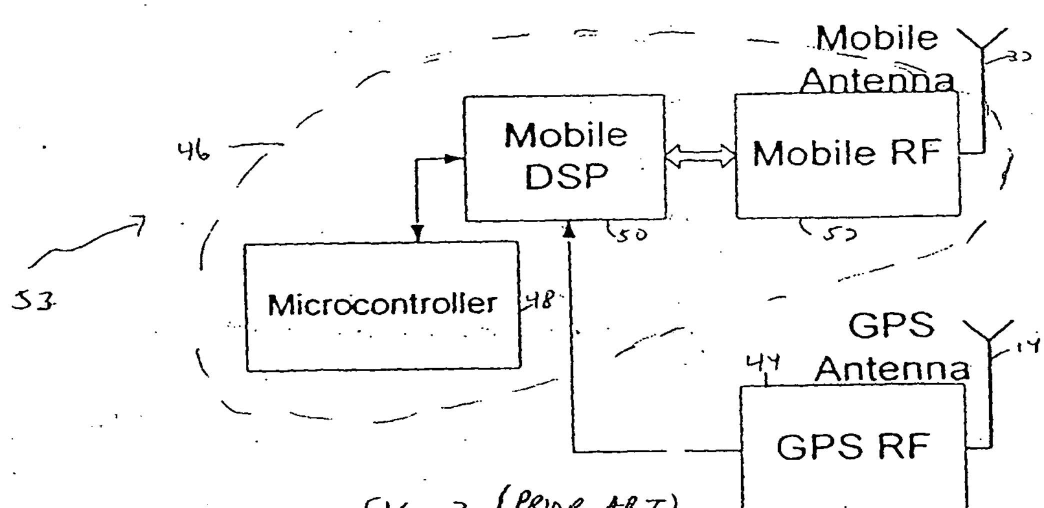
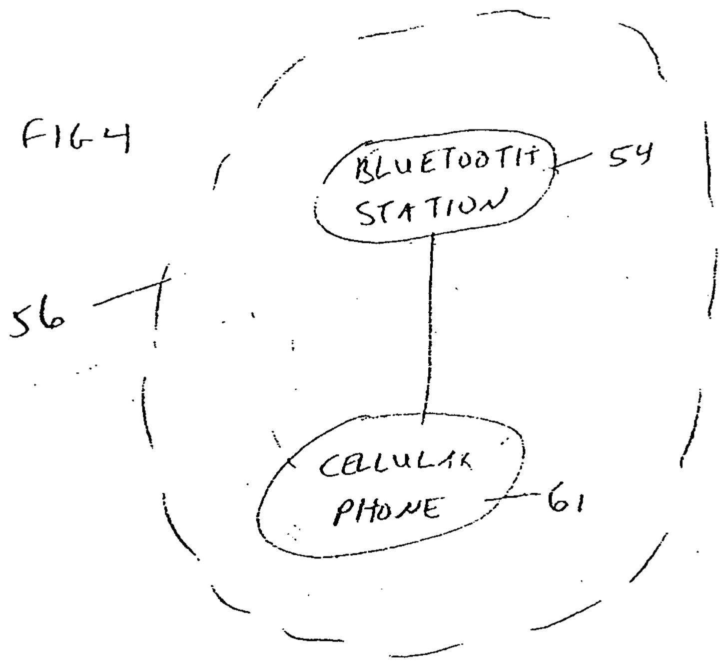


FIG 3 (PRIOR ART)

FIG 4


BLUETOOTH STATION
54
56
CELLULAR PHONE
61

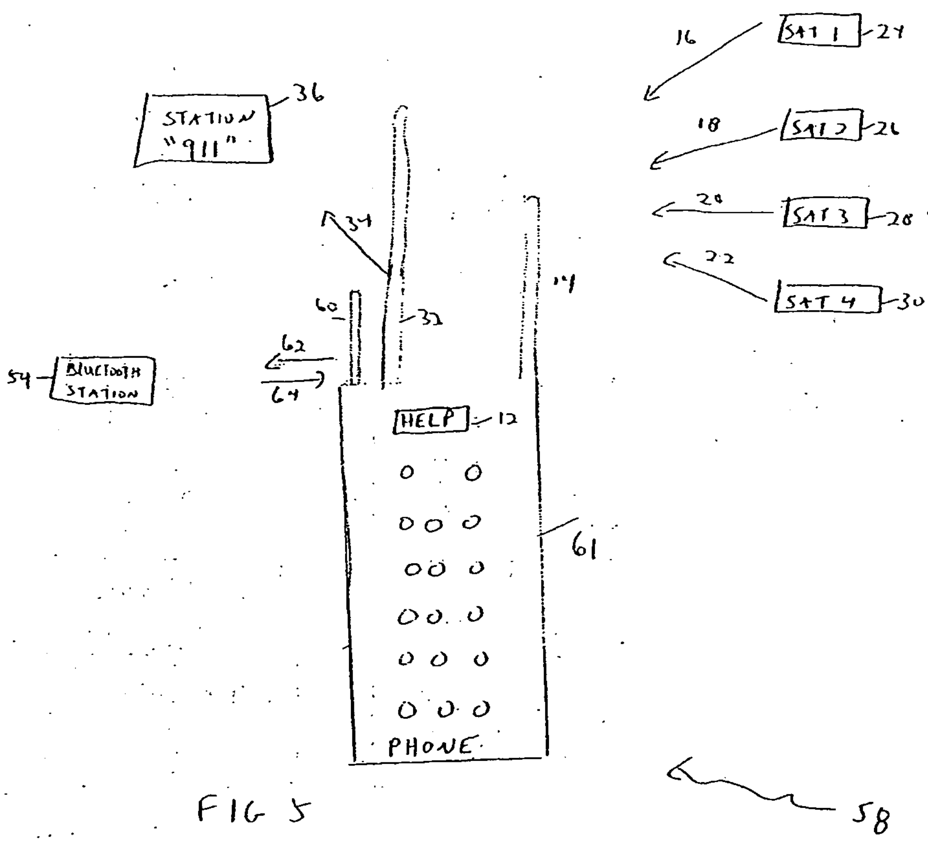

SAT 1
24
16
STATION "911"
36
18
SAT 2
26
20
SAT 3
28
34
22
SAT 4
30
14
60
32
62
54
BLUETOOTH STATION
64
HELP
12
61
PHONE
58

FIG 5

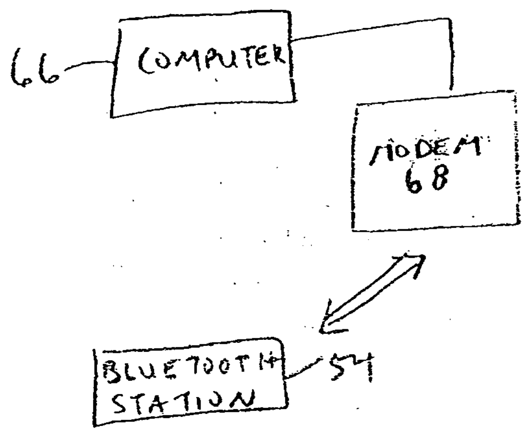

66
COMPUTER
MODEM
68
BLUETOOTH
STATION
54

FIG 6

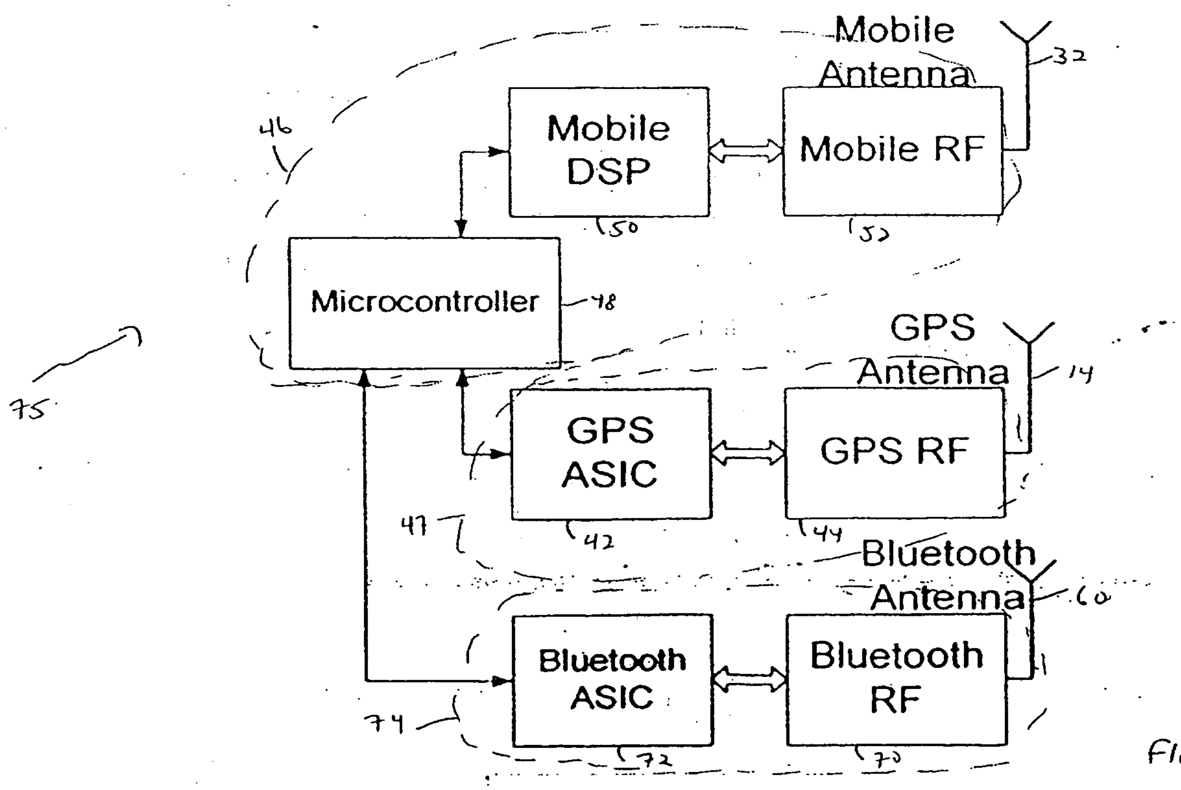

Mobile
Antenna
32
46
Mobile
DSP
Mobile RF
50
52
Microcontroller
48
75
GPS
Antenna
14
GPS
ASIC
GPS RF
47
42
44
Bluetooth
Antenna
60
Bluetooth
ASIC
Bluetooth
RF
74
72
70

FIG 7

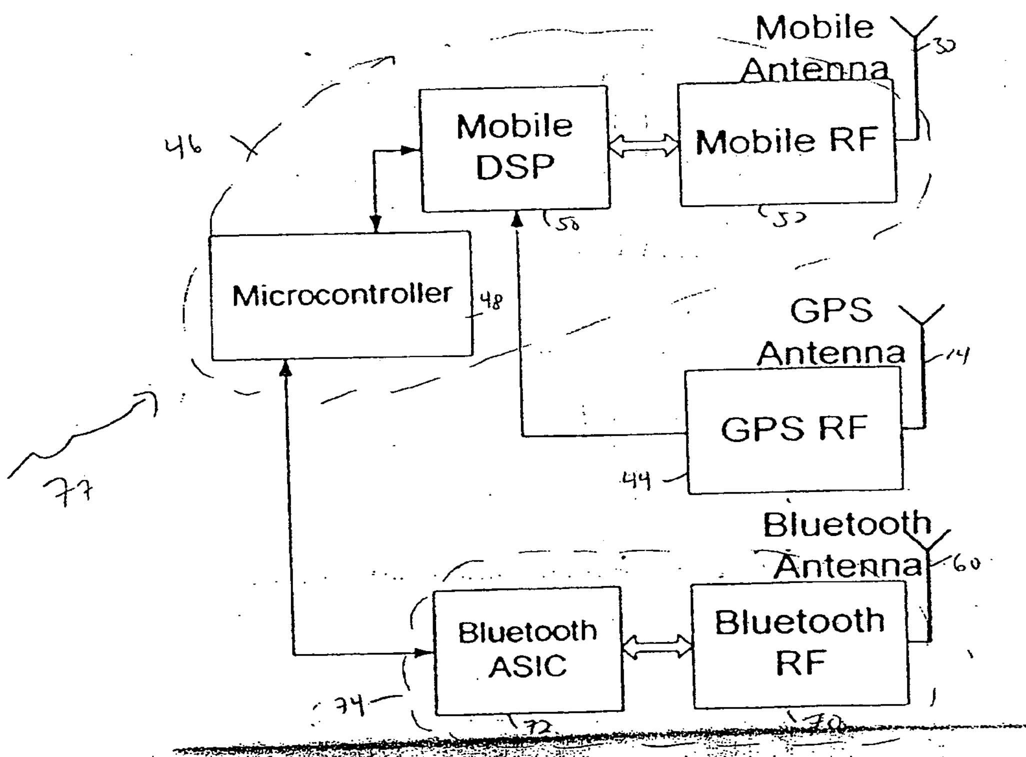

Mobile Antenna
30
46
Mobile DSP
Mobile RF
50
52
Microcontroller
48
GPS Antenna
14
GPS RF
44
77
Bluetooth Antenna
60
Bluetooth ASIC
Bluetooth RF
74
72
70

FIG 8

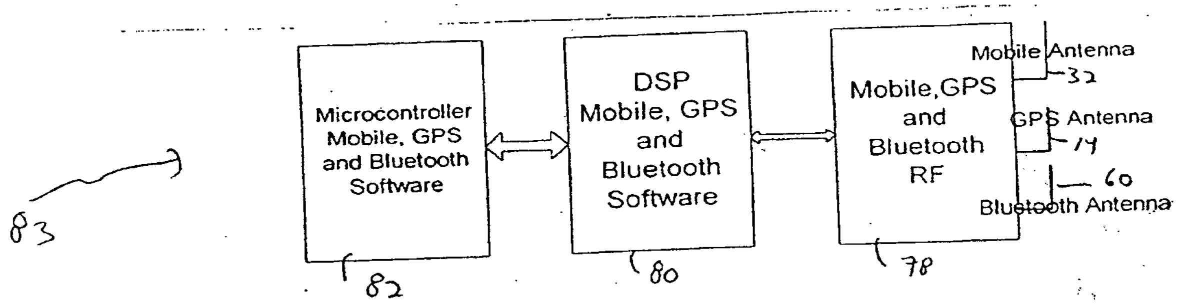

Microcontroller Mobile, GPS and Bluetooth Software
DSP Mobile, GPS and Bluetooth Software
Mobile,GPS and Bluetooth RF
Mobile Antenna
32
GPS Antenna
14
60
Bluetooth Antenna
83
82
80
78

FIG 9

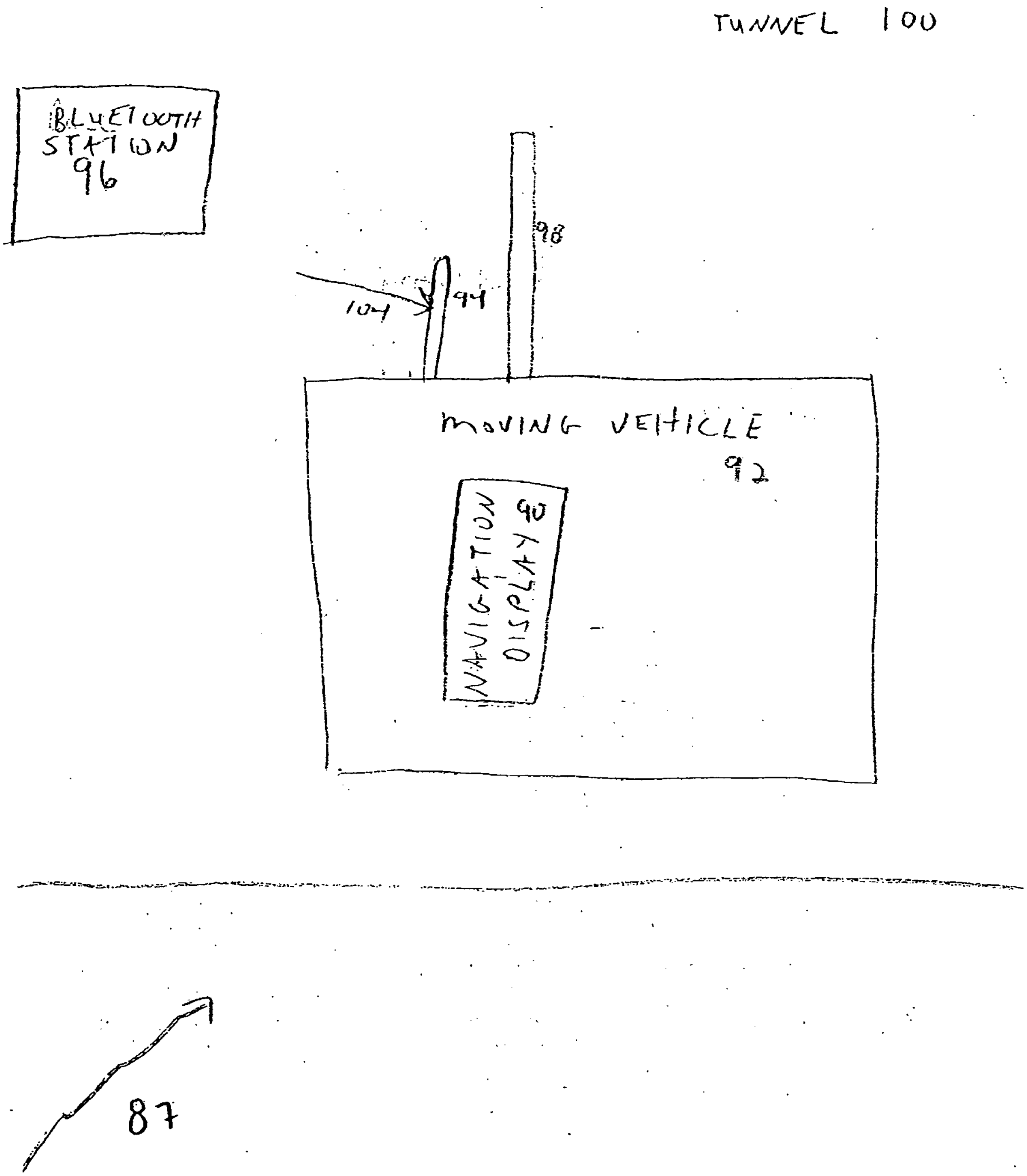

TUNNEL 100
BLUETOOTH STATION 96
98
104
94
MOVING VEHICLE 92
NAVIGATION DISPLAY 90
87

Figure 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/00071

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G01S 5/14
US CL :342/357.1, 357.14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 342/357.1, 357.14, 357.09, 386, 457

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BENNETT, Frazer et al, "PICONET Embedded Mobile Networking" Reading Summary-UBICOMP-Piconet, Spring 1999, pp. 1-23. See entire document. (http://triton.cc.gatech.edu/ubicomp/9)	1-21
X	BENNETT, Frazer et al, "Piconet: Embedded Mobile Networking", IEEE Personal Communications, October 1997. pp. 8-15. See entire document.	1-21
X	HOPPER, Andy, "Preparing for the Digital Media Monsoons", ACM Multimediat 98 Electronic Preceedings, pp. 1-4, see especially page 2.	1

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
10 APRIL 2001	11 MAY 2001

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	GREGORY C. ISSING
Facsimile No. (703) 305-3230	Telephone No. (703) 308-1113

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/00071

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	WANT, Roy et al, "Active Badges and Personal Interactive Computing objects", IEEE Trans. on Consumer Electronics, Vol. 38, No. 1, February 1992, pp. 10-20. See entire document.	1 and 2 ------ 3-21
Y	ALBRECHT, Markus et al, "IP Services over Bluetooth: Leading the Way to a New Mobility", Conf. of Local Computer Networks, 1999. 10/1999. pp. 2-11. See entire document.	1-21
X -- Y	US 5,604,765A (BRUNO et al) 18 February 1997, (18.02.1997) See entire document.	12-21 ----- 1-11

B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

IEEExplore: bluetooth; piconet
EAST: bluetooth and GPS; piconet and GPS
Google: bluetooth and GPS; piconet and GPS
Lycos: bluetooth and GPS; piconet and GPS